

## General Description

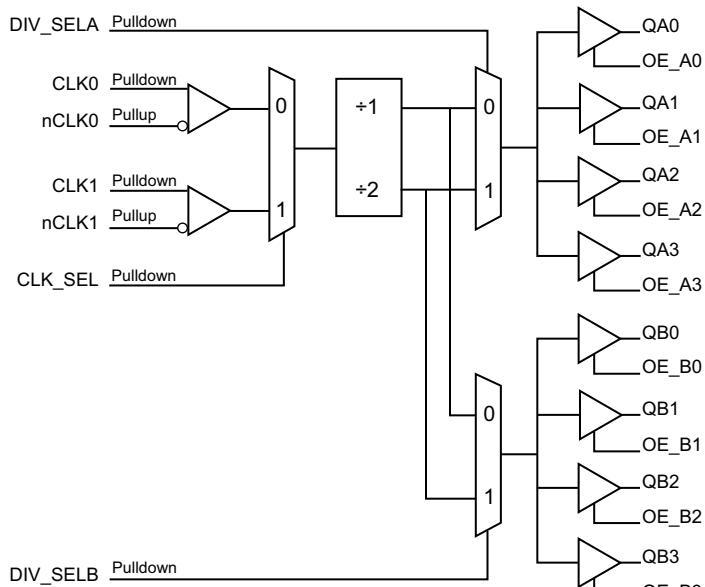
The ICS870S208 is a low skew, eight output LVCMOS / LVTTL Fanout Buffer with selectable divider. The ICS870S208 has two selectable inputs that accept a variety of differential input types. The device provides the capability to suppress any glitch at the outputs of the device during an input clock switch to enhance clock redundancy in fault tolerant applications. The low impedance LVCMOS outputs are designed to drive 50Ω series or parallel terminated transmission lines. The effective fanout can be increased from 8 to 16 by utilizing the ability of the outputs to drive two series terminated lines. The divide select inputs, DIV\_SELA and DIV\_SELB, control the output frequency of each bank. The output banks can be independently selected for  $\div 1$  or  $\div 2$  operation. The output enable pins assigned to each output, support enabling and disabling of each output individually.

The ICS870S208 is characterized at full 3.3V and 2.5V, and mixed 3.3V/2.5V output operating supply modes. Guaranteed output and part-to-part skew characteristics make the ICS870S208 ideal for high performance, single ended applications.

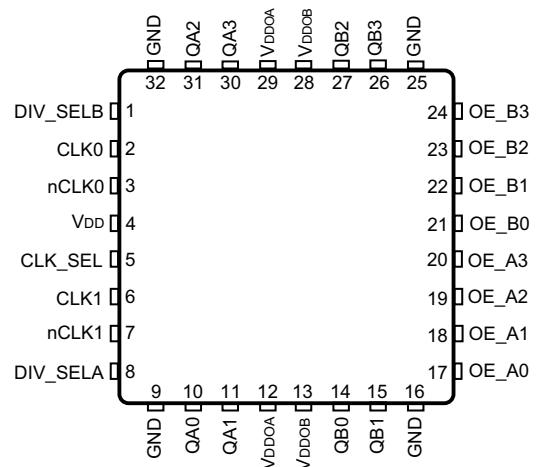
## Features

- Eight LVCMOS/LVTTL outputs, (2 banks of 4 outputs) Each output has individual synchronous output enable
- Two selectable differential CLKx, nCLKx inputs
- Dual differential input pairs can accept the following differential input levels: LVPECL, LVDS, LVHSTL, HCSL
- Maximum output frequency: 250MHz
- Selectable  $\div 1$  or  $\div 2$  operation
- Glitchless output behavior during input switch
- Output skew: 120ps (maximum), 3.3V
- Bank skew: 65ps (maximum), 3.3V
- Supply modes:  
Core/Output  
3.3V/3.3V  
2.5V/2.5V  
3.3V/2.5V
- 0°C to 70°C ambient operating temperature
- Lead-free (RoHS 6) packaging

## Block Diagram



## Pin Assignment



**ICS870S208**  
32-Lead VFQFN  
5mm x 5mm x 0.9mm package body  
3.15mm x 3.15mm EPad Size  
K Package  
Top View

## Pin Descriptions and Characteristics

**Table 1. Pin Descriptions**

Number	Name	Type	Description
1	DIV_SELB	Input	Pulldown
2	CLK0	Input	Pulldown
3	nCLK0	Input	Pullup
4	V <sub>DD</sub>	Power	Power supply pin.
5	CLK_SEL	Input	Pulldown
6	CLK1	Input	Pulldown
7	nCLK1	Input	Pullup
8	DIV_SELA	Input	Pulldown
9, 16, 25, 32	GND	Power	Power supply ground.
10, 11, 30, 31	QA0, QA1, QA3, QA2	Output	Single-ended Bank A clock outputs. LVCMOS / LVTTL interface levels.
12, 29	V <sub>DDOA</sub>	Power	Output supply pins for Bank A outputs.
13, 28	V <sub>DDOB</sub>	Power	Output supply pins for Bank B outputs.
14, 15 26, 27	QB0, QB1, QB3, QB2	Output	Single-ended Bank B clock outputs. LVCMOS / LVTTL interface levels.
17	OE_A0	Input	Pullup
18	OE_A1	Input	Pullup
19	OE_A2	Input	Pullup
20	OE_A3	Input	Pullup
21	OE_B0	Input	Pullup
22	OE_B1	Input	Pullup
23	OE_B2	Input	Pullup
24	OE_B3	Input	Pullup

NOTE: *Pullup* and *Pulldown* refer to internal input resistors. See Table 2, *Pin Characteristics*, for typical values.

**Table 2. Pin Characteristics**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$C_{IN}$	Input Capacitance			2		pF
$C_{PD}$	Power Dissipation Capacitance (per output)	$V_{DD} = V_{DDOA, B} = 3.465V$		8		pF
		$V_{DD} = V_{DDOA, B} = 2.625V$		7		pF
		$V_{DD} = 3.465V, V_{DDOA, B} = 2.625V$		7		pF
$R_{PULLUP}$	Input Pullup Resistor			50		k $\Omega$
$R_{PULLDOWN}$	Input Pulldown Resistor			50		k $\Omega$
$R_{OUT}$	Output Impedance			15		$\Omega$

## Function Tables

**Table 3. Output Enable Function Table**

Control Inputs	Outputs
$OE_x [0:3]$	$QA[0:3], QB[0:3]$
0	High-Impedance
1 (default)	Active

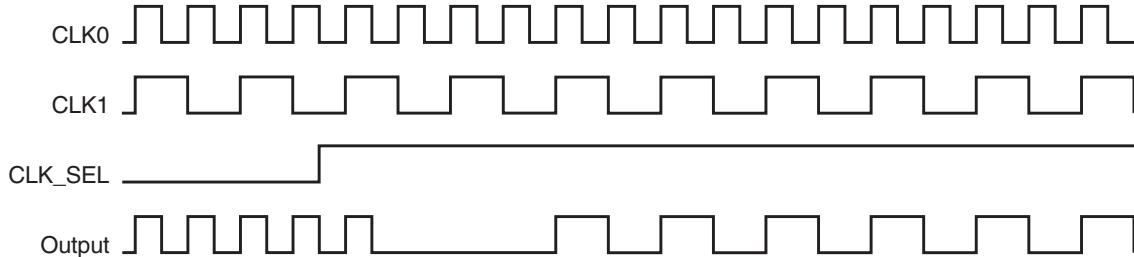
NOTE: Where x = A or B.

## Function Description

### Two Valid Clocks

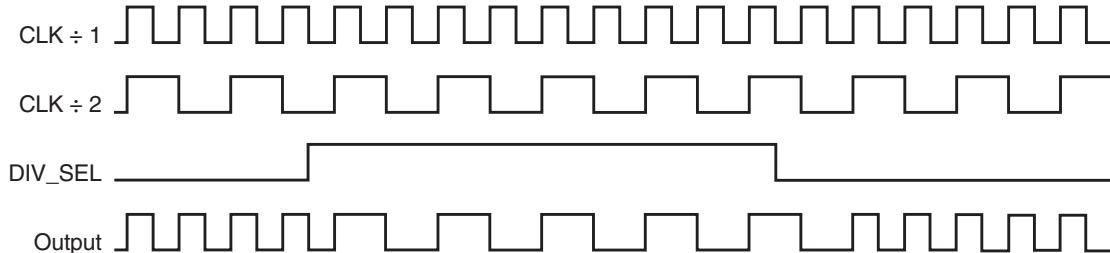
The ICS87S0208 has a glitch free input mux that is controlled by the CLK\_SEL pin. It is designed to switch between 2 input clocks whether running or not. In the case where both clocks are running, when CLK\_SEL changes, the output clocks go low after one cycle of

the output clock (nominally). The outputs then stay low for one cycle of the new input clock (nominally) and then begin to follow the new input clock. This is shown in *Figure 1A*.



**Figure 1A. CLK\_SEL Timing Diagram**

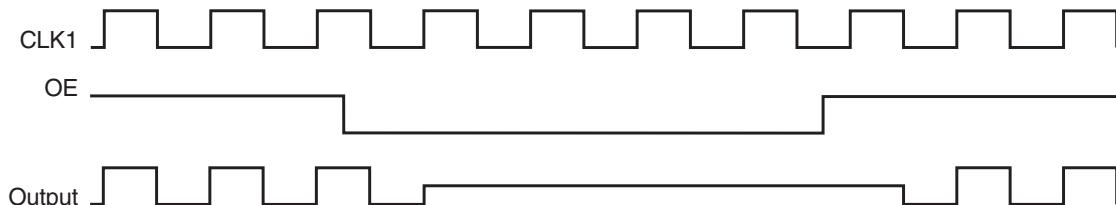
When DIV\_SEL changes, the part waits for the output to complete the cycle of the selected divider then changes seamlessly to the new divider.



**Figure 1B. DIV\_SELx Timing Diagram**

When an output enable pin is pulled low, the part waits for the output to complete its period, then transitions to an High-Impedance state. When output enable is asserted, the output transitions from a

High-Impedance to a low state to ensure a clean rising edge of the first output clock.



**Figure 1C. OEx Timing Diagram**

## Bad Input Clock

An internal timer monitors the state of both input clocks. If a clock is stopped (stuck high or low for over approximately 200ns), its internal input bad flag is set and the part will perform as depicted in the following diagrams. If the clock is restored, the internal input bad detector waits for 4 full clock periods before clearing the input bad flag and returning to normal operation.

If the selected input clock goes bad (stuck high or low for over approximately 200ns), an internal input bad flag is set. When the input bad flag is set, the output goes low until the next valid clock event. If the selected clock is restored, the input bad detector waits 4 full clock periods before clearing the flag and returning to normal operation. If CLK\_SEL is changed to select a valid input clock, the output will stay low for one full period of the new input clock, then return to normal operation.

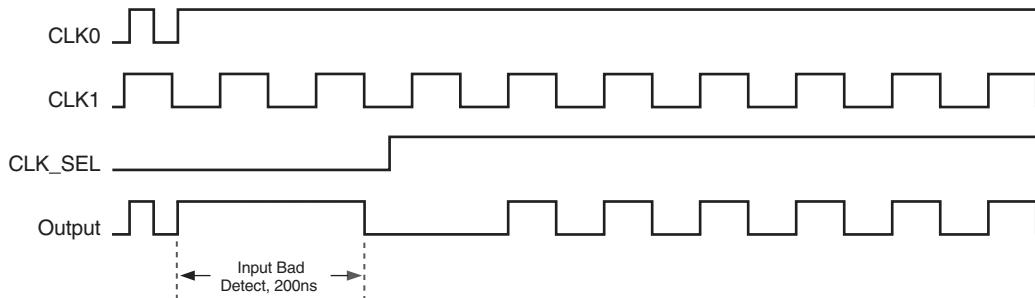


Figure 1D. CLK\_SEL with Bad Input Timing Diagram

If the selected input clock goes bad (stuck high or low for over approximately 200ns), an internal input bad flag is set. When the input bad flag is set, the output goes low until the next valid clock

event. If DIV\_SEL is changed, the output will transition from the low state following the selected divide when a valid input clock is restored.

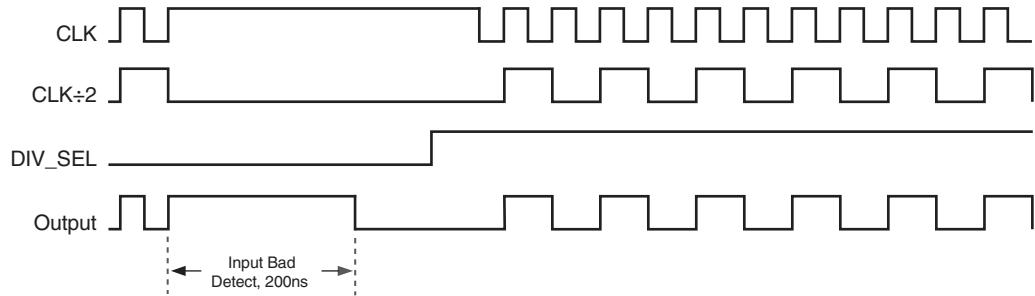


Figure 1E. DIV\_SELx with Bad Input Timing Diagram

If the input bad flag has been set (The input has been stuck high or low for over approximately 200ns), and OEx is pulled low, the output will immediately go to a High-Impedance state. If the clock is restored

while the OEx is low, the output will transition from the High-Impedance to a low state to ensure a clean rising edge of the first output clock when the Oex is pulled high again.

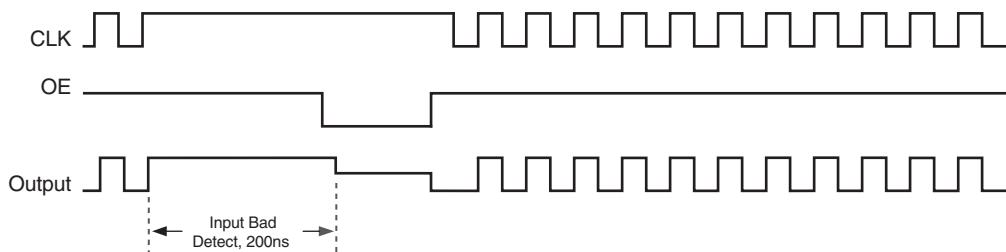


Figure 1F. OEx with Bad Input Timing Diagram

## Switch During an Input Bad Detect

If a CLK\_SEL, DIV\_SEL, or OE event happens after a clock has stopped, but before the input bad flag has been set (during the ~200ns detect period) the output change will not take effect until the internal bad flag has been set. The output will go low after the input

bad flag is set and follow the second period of the new clock input. Although no glitches will occur, due to the unknown state of the failing clock, a transition may take up to 1us to execute.

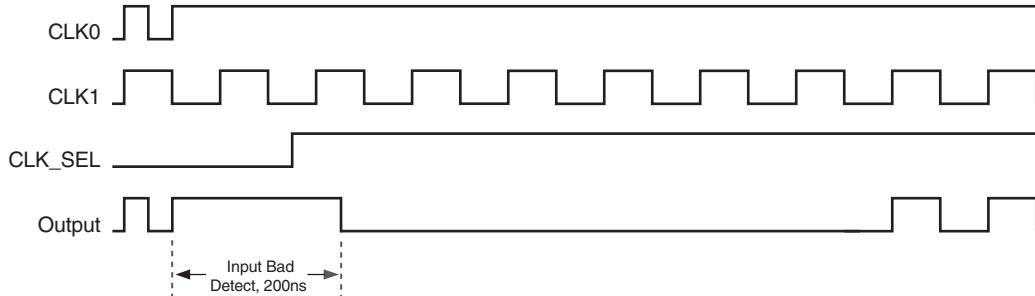


Figure 1G. CLK\_SEL with Bad Input Timing Diagram

## Absolute Maximum Ratings

NOTE: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

Item	Rating
Supply Voltage, $V_{DD}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DD} + 0.5V$
Outputs, $V_O$	-0.5V to $V_{DDOA, B} + 0.5V$
Package Thermal Impedance, $\theta_{JA}$	42.7°C/W (0 mps)
Storage Temperature, $T_{STG}$	-65°C to 150°C

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{DD} = V_{DDOA} = V_{DDOB} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Power Supply Voltage		3.135	3.3	3.465	V
$V_{DDOA}, V_{DDOB}$	Output Supply Voltage		3.135	3.3	3.465	V
$I_{DD}$	Power Supply Current				80	mA
$I_{DDOA}, I_{DDOB}$	Output Supply Current	No Load			1	mA

**Table 4B. Power Supply DC Characteristics,  $V_{DD} = V_{DDOA} = V_{DDOB} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Power Supply Voltage		2.375	2.5	2.625	V
$V_{DDOA}, V_{DDOB}$	Output Supply Voltage		2.375	2.5	2.625	V
$I_{DD}$	Power Supply Current				80	mA
$I_{DDOA}, I_{DDOB}$	Output Supply Current	No Load			1	mA

**Table 4C. Power Supply DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDOA} = V_{DDOB} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Power Supply Voltage		3.135	3.3	3.465	V
$V_{DDOA}, V_{DDOB}$	Output Supply Voltage		2.375	2.5	2.625	V
$I_{DD}$	Power Supply Current				80	mA
$I_{DDOA}, I_{DDOB}$	Output Supply Current	No Load			1	mA

**Table 4D. LVCMS/LVTTL DC Characteristics,  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage	$V_{DD} = 3.3V \pm 5\%$	2.2		$V_{DD} + 0.3$	V
		$V_{DD} = 2.5V \pm 5\%$	1.7		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage	$V_{DD} = 3.3V \pm 5\%$	-0.3		0.8	V
		$V_{DD} = 2.5V \pm 5\%$	-0.3		0.7	V
$I_{IH}$	Input High Current	$V_{DD} = V_{IN} = 3.465V$ or $2.625V$			150	$\mu\text{A}$
		$V_{DD} = V_{IN} = 3.465V$ or $2.625V$			10	$\mu\text{A}$
$I_{IL}$	Input Low Current	$V_{DD} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$	-10			$\mu\text{A}$
		$V_{DD} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$	-150			$\mu\text{A}$
$V_{OH}$	Output High Voltage; NOTE 1	$V_{DDOA}, V_{DDOB} = 3.465V$	2.6			V
		$V_{DDOA}, V_{DDOB} = 2.625V$	1.8			V
$V_{OL}$	Output Low Voltage; NOTE 1	$V_{DDOA}, V_{DDOB} = 3.465V$ or $2.625V$			0.55	V

NOTE 1: Outputs are terminated with  $50\Omega$  to  $V_{DDOA, B}/2$ . See Parameter Measurement section, *Load Test Circuit* diagrams.

**Table 4E. Differential DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	$V_{DD} = V_{IN} = 3.465V$ or $2.625V$			10	$\mu\text{A}$
		$V_{DD} = V_{IN} = 3.465V$ or $2.625V$			150	$\mu\text{A}$
$I_{IL}$	Input Low Current	$V_{DD} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$	-150			$\mu\text{A}$
		$V_{DD} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$	-10			$\mu\text{A}$
$V_{PP}$	Peak-to-Peak Voltage; NOTE 1		0.15		1.3	V
$V_{CMR}$	Common Mode Input Voltage; NOTE 1, 2		$GND + 0.5$		$V_{DD} - 0.85$	V

NOTE 1:  $V_{IL}$  should not be less than -0.3V.

NOTE 2: Common mode input voltage is defined as  $V_{IH}$ .

## AC Electrical Characteristics

**Table 5A. AC Characteristics,  $V_{DD} = V_{DDOA} = V_{DDOB} = 3.3V \pm 5\% = T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{out}$	Output Frequency				250	MHz
$t_{PD}$	Propagation Delay; NOTE 1		2.3		3.8	ns
$t_{sk(o)}$	Output Skew; NOTE 2, 3				120	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4				225	ps
$t_{sk(b)}$	Bank Skew; NOTE 3, 5	QA[0:3], nQA[0:3]			65	ps
		QB[0:3], nQB[0:3]			60	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	150		600	ps
$t_{EN}$	Output Enable Time; NOTE 6				10	ns
$t_{DIS}$	Output Disable Time; NOTE 6				10	ns
$odc$	Output Duty Cycle		45		55	%

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: Measured from the differential input crosspoint to  $V_{DDOA, B/2}$  of the output.

NOTE 2: Defined as between outputs at the same supply voltage and with equal load conditions. Measured at  $V_{DDOA, B/2}$ .

NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 4: Defined as skew between outputs on different devices operating at the same supply voltage, same temperature, same frequency and with equal load conditions. Using the same type of input on each device, the output is measured at  $V_{DDOA, B/2}$ .

NOTE 5: Defined as skew within a bank of outputs at the same voltage and with equal load conditions.

NOTE 6: These parameters are guaranteed by characterization. Not tested in production.

**Table 5B. AC Characteristics,  $V_{DD} = V_{DDOA} = V_{DDOB} = 2.5V \pm 5\%, T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{out}$	Output Frequency				250	MHz
$t_{PD}$	Propagation Delay; NOTE 1		2.4		4.0	ns
$t_{sk(o)}$	Output Skew; NOTE 2, 3				135	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4				225	ps
$t_{sk(b)}$	Bank Skew; NOTE 3, 5	QA[0:3], nQA[0:3]			70	ps
		QB[0:3], nQB[0:3]			60	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	150		600	ps
$t_{EN}$	Output Enable Time; NOTE 6				10	ns
$t_{DIS}$	Output Disable Time; NOTE 6				10	ns
$odc$	Output Duty Cycle		44		56	%

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: Measured from the differential input crosspoint to  $V_{DDOA, B/2}$  of the output.

NOTE 2: Defined as between outputs at the same supply voltage and with equal load conditions. Measured at  $V_{DDOA, B/2}$ .

NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 4: Defined as skew between outputs on different devices operating at the same supply voltage, same temperature, same frequency and with equal load conditions. Using the same type of input on each device, the output is measured at  $V_{DDOA, B/2}$ .

NOTE 5: Defined as skew within a bank of outputs at the same voltage and with equal load conditions.

NOTE 6: These parameters are guaranteed by characterization. Not tested in production.

**Table 5C. AC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDOA} = V_{DDOB} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{out}$	Output Frequency				250	MHz
$t_{PD}$	Propagation Delay; NOTE 1		2.5		4.1	ns
$t_{sk(o)}$	Output Skew; NOTE 2, 3				140	ps
$t_{sk(pp)}$	Part-to-Part Skew; NOTE 3, 4				225	ps
$t_{sk(b)}$	Bank Skew; NOTE 3, 5	QA[0:3], nQA[0:3]			70	ps
		QB[0:3], nQB[0:3]			60	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	150		600	ps
$t_{EN}$	Output Enable Time; NOTE 6				10	ns
$t_{DIS}$	Output Disable Time; NOTE 6				10	ns
$odc$	Output Duty Cycle		40		60	%

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 Ifpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: Measured from the differential input crosspoint to  $V_{DDOA, B/2}$  of the output.

NOTE 2: Defined as between outputs at the same supply voltage and with equal load conditions. Measured at  $V_{DDOA, B/2}$ .

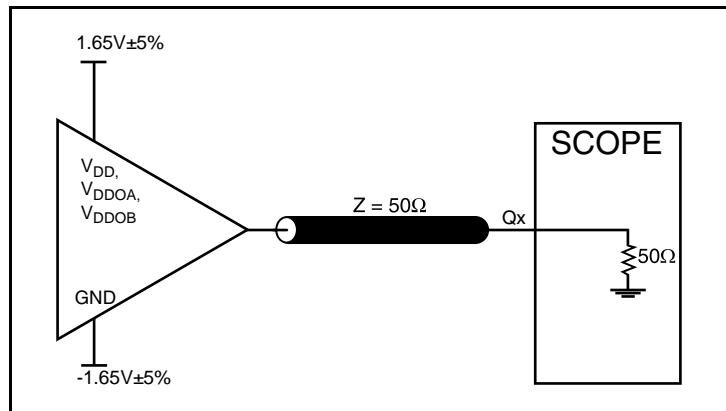
NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 4: Defined as skew between outputs on different devices operating at the same supply voltage, same temperature, same frequency and with equal load conditions. Using the same type of input on each device, the output is measured at  $V_{DDOA, B/2}$ .

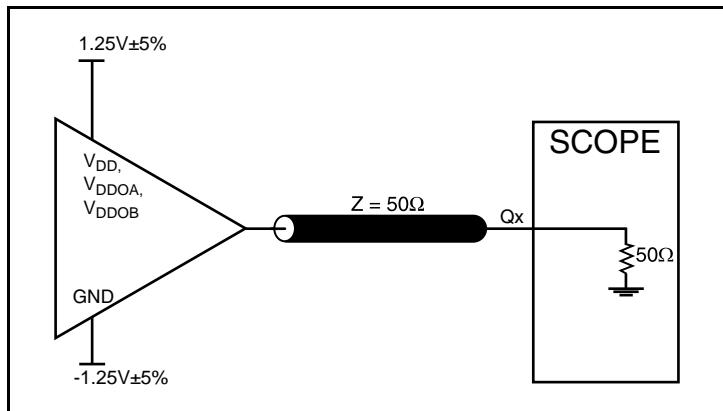
NOTE 5: Defined as skew within a bank of outputs at the same voltage and with equal load conditions.

NOTE 6: These parameters are guaranteed by characterization. Not tested in production.

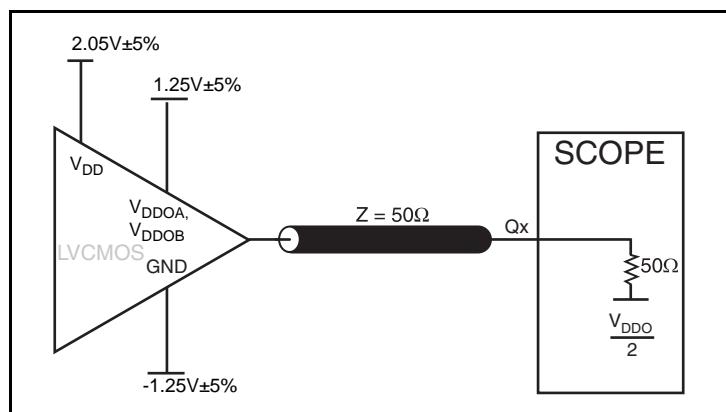
## Parameter Measurement Information



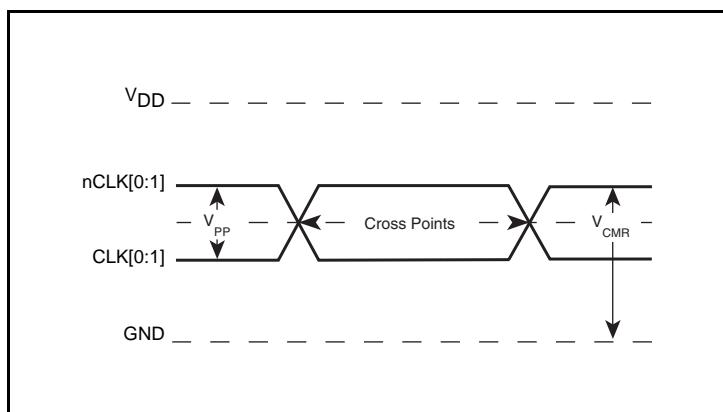
### 3.3V Output Load Test Circuit



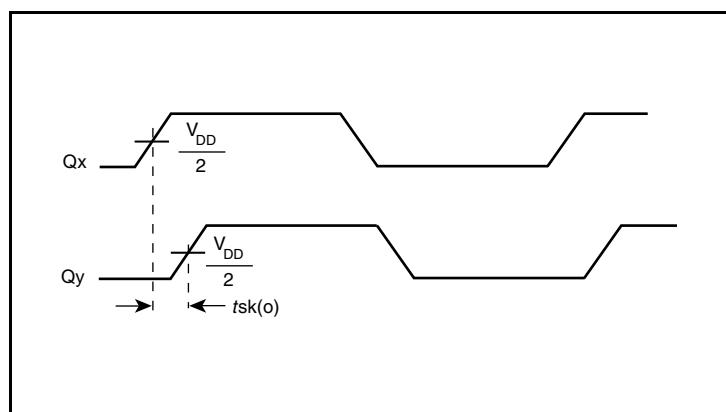
## 2.5V Output Load Test Circuit



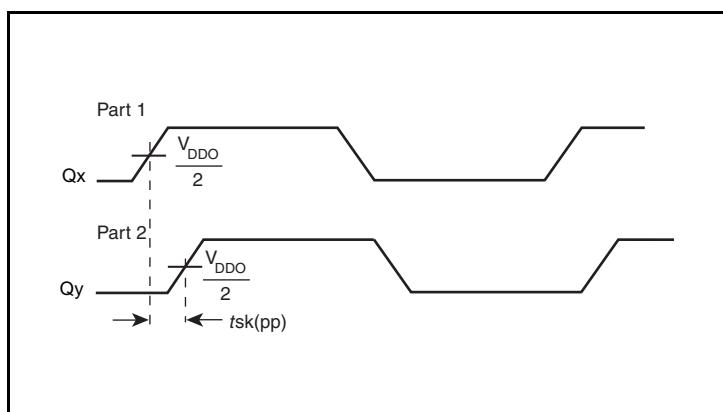
### 3.3V Core/2.5V Output Load Test Circuit



## Differential Input Level

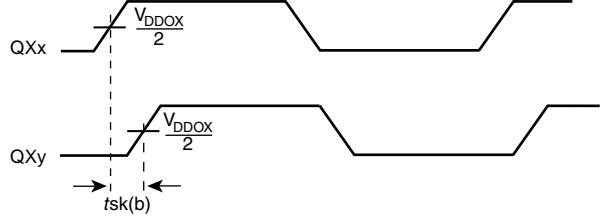


## Output Skew



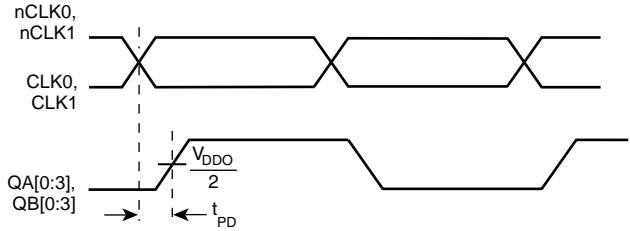
## Part-to-Part Skew

## Parameter Measurement Information, continued

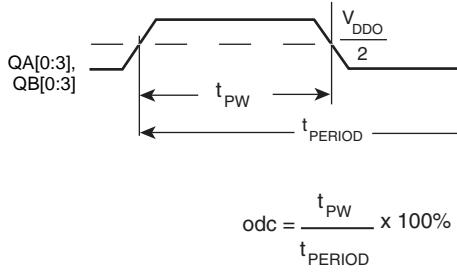


Where X denotes Bank A or Bank B outputs

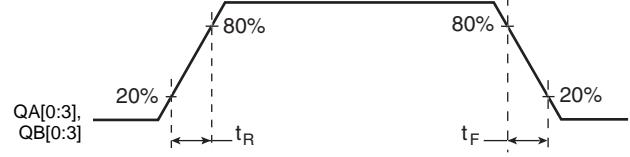
**Bank Skew**



**Propagation Delay**



**Output Duty Cycle/Pulse Width/Period**



**Output Rise/Fall Time**

## Applications Information

### Recommendations for Unused Input and Output Pins

#### Inputs:

##### CLK/nCLK Inputs

For applications not requiring the use of the differential input, both CLK<sub>x</sub> and nCLK<sub>x</sub> can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from CLK<sub>x</sub> to ground.

##### LVC MOS Control Pins

All control pins have internal pullups or pulldowns; additional resistance is not required but can be added for additional protection. A 1kΩ resistor can be used.

#### Outputs:

##### LVC MOS Outputs

All unused LVC MOS output can be left floating. There should be no trace attached.

## Wiring the Differential Input to Accept Single-Ended Levels

Figure 2 shows how a differential input can be wired to accept single ended levels. The reference voltage  $V_1 = V_{DD}/2$  is generated by the bias resistors R1 and R2. The bypass capacitor (C1) is used to help filter noise on the DC bias. This bias circuit should be located as close to the input pin as possible. The ratio of R1 and R2 might need to be adjusted to position the  $V_1$  in the center of the input voltage swing. For example, if the input clock swing is 2.5V and  $V_{DD} = 3.3V$ , R1 and R2 value should be adjusted to set  $V_1$  at 1.25V. The values below are for when both the single ended swing and  $V_{DD}$  are at the same voltage. This configuration requires that the sum of the output impedance of the driver (Ro) and the series resistance (Rs) equals the transmission line impedance. In addition, matched termination at the input will attenuate the signal in half. This can be done in one of two ways. First, R3 and R4 in parallel should equal the transmission line

impedance. For most 50Ω applications, R3 and R4 can be 100Ω. The values of the resistors can be increased to reduce the loading for slower and weaker LVC MOS driver. When using single-ended signaling, the noise rejection benefits of differential signaling are reduced. Even though the differential input can handle full rail LVC MOS signaling, it is recommended that the amplitude be reduced. The datasheet specifies a lower differential amplitude, however this only applies to differential signals. For single-ended applications, the swing can be larger, however  $V_{IL}$  cannot be less than -0.3V and  $V_{IH}$  cannot be more than  $V_{DD} + 0.3V$ . Though some of the recommended components might not be used, the pads should be placed in the layout. They can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a differential signal.

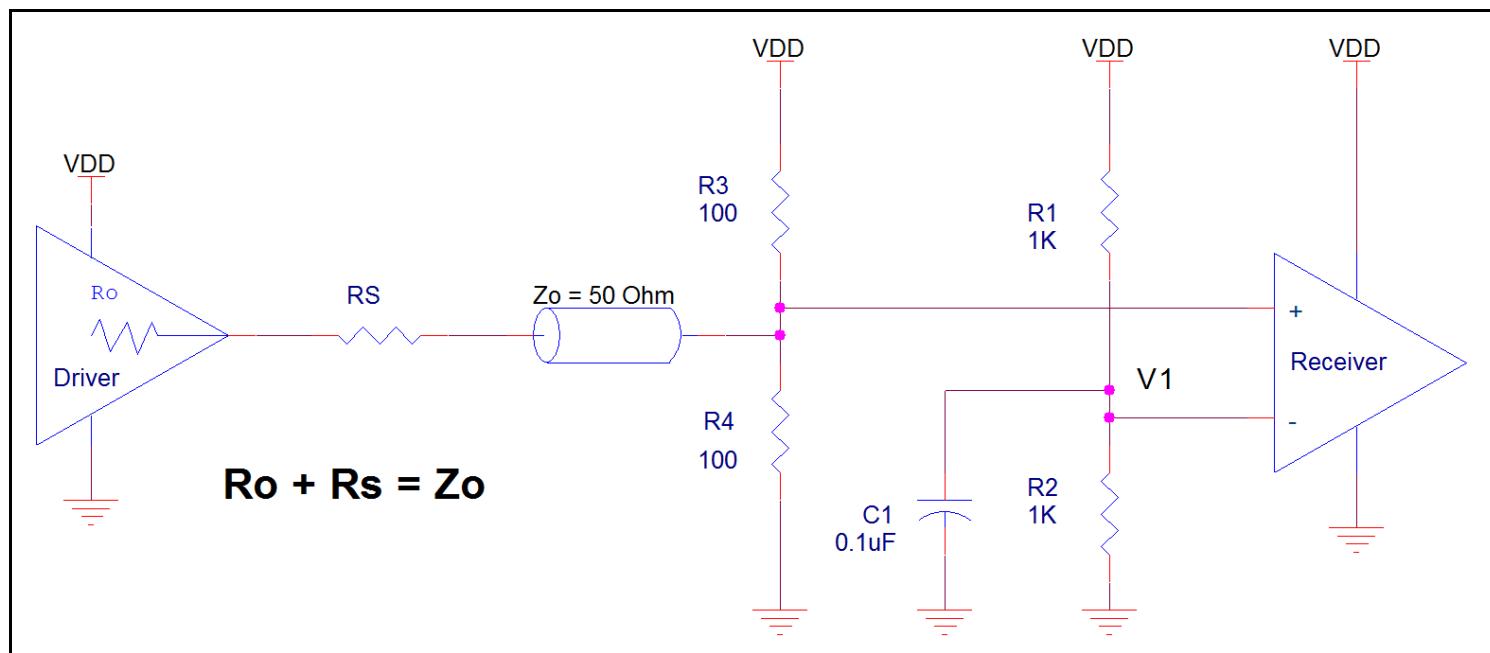
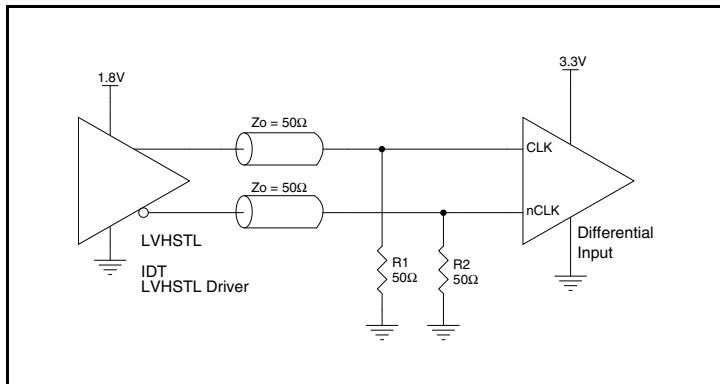


Figure 2. Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels

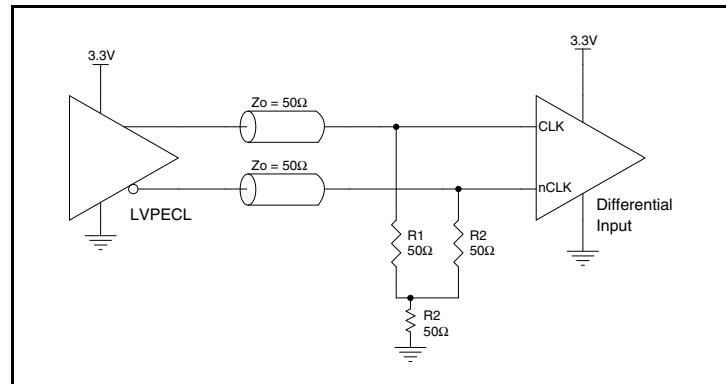
## Differential Clock Input Interface

The CLKx /nCLKx accepts LVDS, LVPECL, LVHSTL, HCSL and other differential signals. Both signals must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. Figures 3A to 3E show interface examples for the CLKx/nCLKx input driven by the most common driver types. The input interfaces suggested here are examples only. Please consult

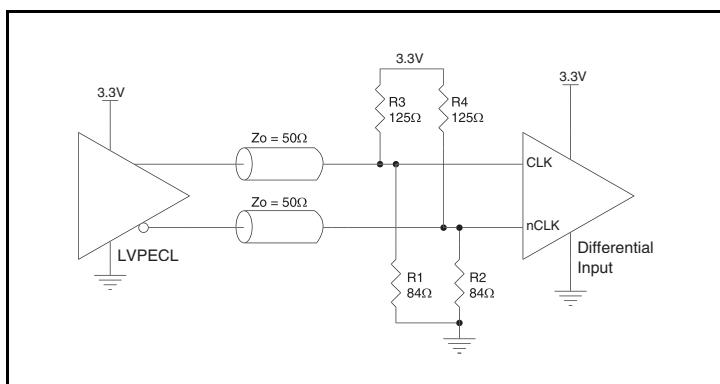
with the vendor of the driver component to confirm the driver termination requirements. For example, in Figure 3A, the input termination applies for IDT open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



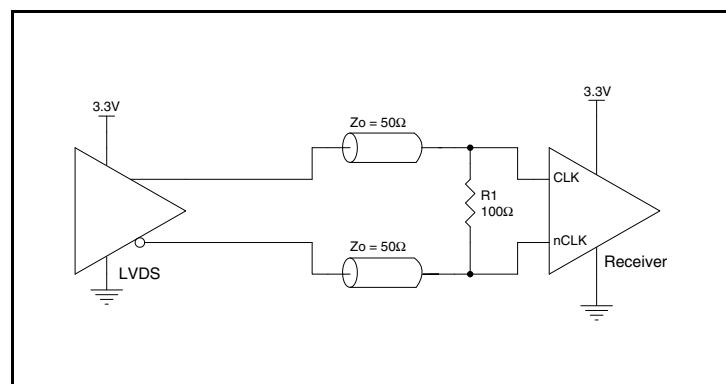
**Figure 3A. CLK/nCLK Input Driven by an IDT Open Emitter LVHSTL Driver**



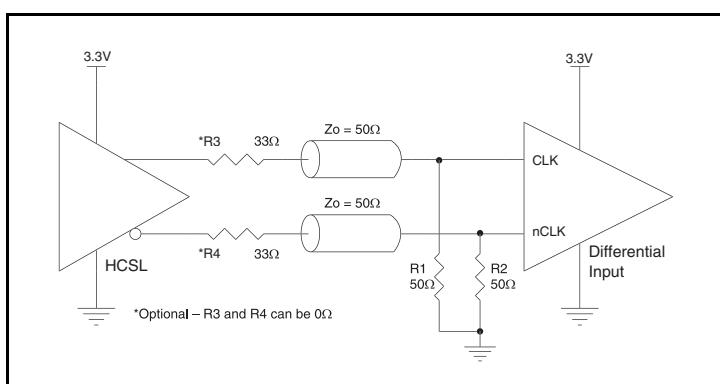
**Figure 3B. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



**Figure 3C. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



**Figure 3D. CLK/nCLK Input Driven by a 3.3V LVDS Driver**



**Figure 3E. CLK/nCLK Input Driven by a 3.3V HCSL Driver**

## VFQFN EPAD Thermal Release Path

In order to maximize both the removal of heat from the package and the electrical performance, a land pattern must be incorporated on the Printed Circuit Board (PCB) within the footprint of the package corresponding to the exposed metal pad or exposed heat slug on the package, as shown in *Figure 4*. The solderable area on the PCB, as defined by the solder mask, should be at least the same size/shape as the exposed pad/slug area on the package to maximize the thermal/electrical performance. Sufficient clearance should be designed on the PCB between the outer edges of the land pattern and the inner edges of pad pattern for the leads to avoid any shorts.

While the land pattern on the PCB provides a means of heat transfer and electrical grounding from the package to the board through a solder joint, thermal vias are necessary to effectively conduct from the surface of the PCB to the ground plane(s). The land pattern must be connected to ground through these vias. The vias act as "heat pipes". The number of vias (i.e. "heat pipes") are application specific

and dependent upon the package power dissipation as well as electrical conductivity requirements. Thus, thermal and electrical analysis and/or testing are recommended to determine the minimum number needed. Maximum thermal and electrical performance is achieved when an array of vias is incorporated in the land pattern. It is recommended to use as many vias connected to ground as possible. It is also recommended that the via diameter should be 12 to 13mils (0.30 to 0.33mm) with 1oz copper via barrel plating. This is desirable to avoid any solder wicking inside the via during the soldering process which may result in voids in solder between the exposed pad/slug and the thermal land. Precautions should be taken to eliminate any solder voids between the exposed heat slug and the land pattern. Note: These recommendations are to be used as a guideline only. For further information, please refer to the Application Note on the Surface Mount Assembly of Amkor's Thermally/Electrically Enhance Leadframe Base Package, Amkor Technology.

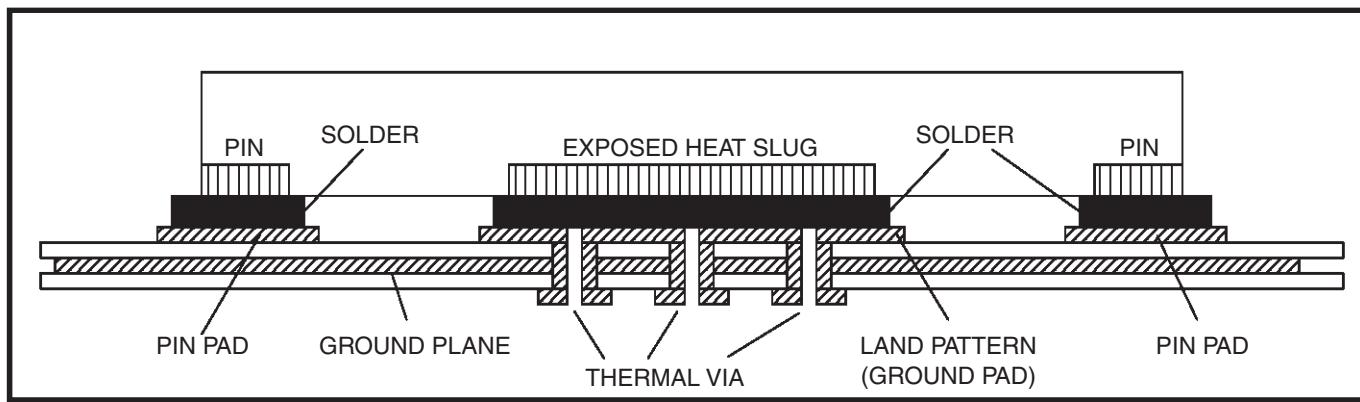


Figure 4. P.C. Assembly for Exposed Pad Thermal Release Path – Side View (drawing not to scale)

## Power Considerations

This section provides information on power dissipation and junction temperature for the ICS870S208. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS870S208 is the sum of the core power plus the analog power plus the power dissipated due to loading into the load. The following is the power dissipation for  $V_{DD} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * I_{DD} = 3.465V * 80mA = 277.2mW$
- Output Impedance  $R_{OUT}$  Power Dissipation due to Loading  $50\Omega$  to  $V_{DD}/2$   
Output Current  $I_{OUT} = V_{DD\_MAX} / [2 * (50\Omega + R_{OUT})] = 3.465V / [2 * (50\Omega + 15\Omega)] = 26.7mA$
- Power Dissipation on the  $R_{OUT}$  per LVC MOS output  
Power ( $R_{OUT}$ ) =  $R_{OUT} * (I_{OUT})^2 = 15\Omega * (26.7mA)^2 = 10.69mW$  per output
- Total Power ( $R_{OUT}$ ) =  $10.69mW * 8 = 85.52mW$

#### Dynamic Power Dissipation at 250MHz

$$\text{Power (250MHz)} = C_{PD} * \text{Frequency} * (V_{DD})^2 = 8pF * 250\text{MHz} * (3.465V)^2 = 24mW \text{ per output}$$

$$\text{Total Power (250MHz)} = 24mW * 8 = 192mW$$

#### Total Power Dissipation

- **Total Power**  
= Power (core)<sub>MAX</sub> + Power ( $R_{OUT}$ ) + Power (250MHz)  
=  $277.2mW + 85.52mW + 192mW$   
= **554.72mW**

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature is  $125^\circ\text{C}$ . Limiting the internal transistor junction temperature,  $T_j$ , to  $125^\circ\text{C}$  ensures that the bond wire and bond pad temperature remains below  $125^\circ\text{C}$ .

The equation for  $T_j$  is as follows:  $T_j = \theta_{JA} * P_{d\_total} + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

$P_{d\_total}$  = Total Device Power Dissipation (example calculation is in section 1 above)

$T_A$  = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is  $42.7^\circ\text{C/W}$  per Table 6 below.

Therefore,  $T_j$  for an ambient temperature of  $70^\circ\text{C}$  with all outputs switching is:

$$70^\circ\text{C} + 0.555W * 42.7^\circ\text{C/W} = 93.7^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

This calculation is only an example.  $T_j$  will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

**Table 6. Thermal Resistance  $\theta_{JA}$  for 32 Lead VFQFN, Forced Convection**

$\theta_{JA}$ by Velocity			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	$42.7^\circ\text{C/W}$	$37.3^\circ\text{C/W}$	$33.5^\circ\text{C/W}$

## Reliability Information

**Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 32 Lead VFQFN**

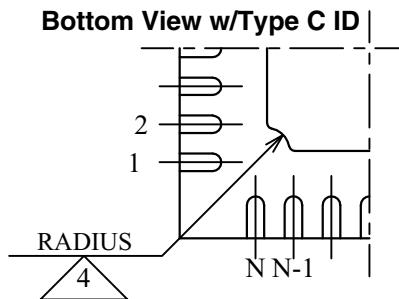
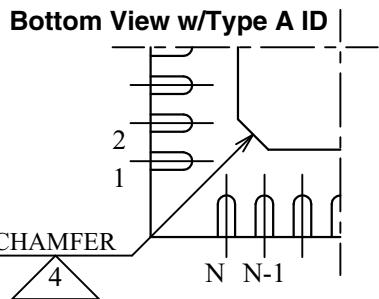
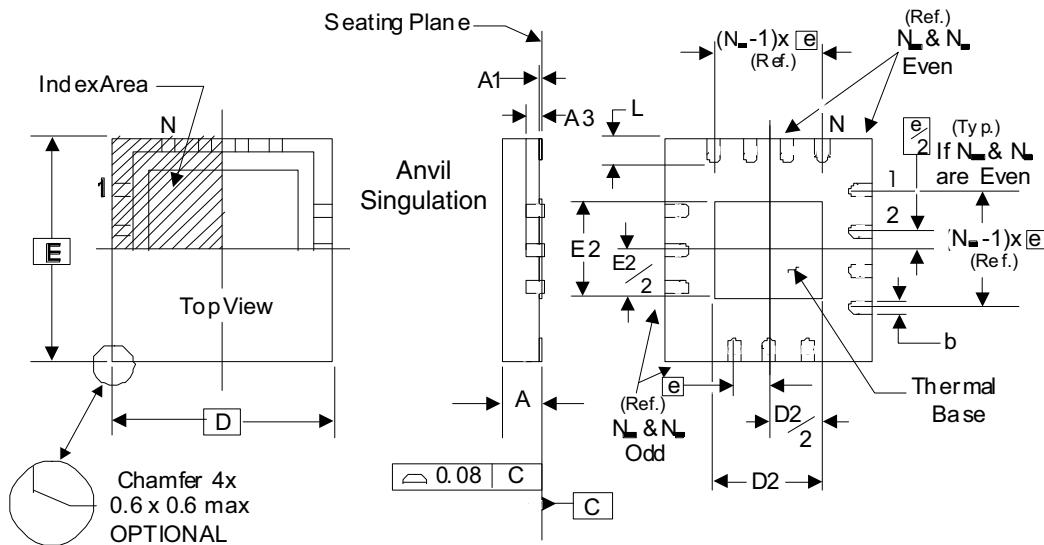
$\theta_{JA}$ vs. Air Flow			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	42.7°C/W	37.3°C/W	33.5°C/W

## Transistor Count

The transistor count for ICS870S208 is: 2788

## Package Outline and Package Dimensions

### Package Outline - K Suffix for 32 Lead VFQFN



There are 2 methods of indicating pin 1 corner at the back of the VFQFN package:

1. Type A: Chamfer on the paddle (near pin 1)
2. Type C: Mouse bite on the paddle (near pin 1)

**Table 8. Package Dimensions**

JEDEC Variation: VHHD-2/4 All Dimensions in Millimeters			
Symbol	Minimum	Nominal	Maximum
N	32		
A	0.80		1.00
A1	0		0.05
A3	0.25 Ref.		
b	0.18	0.25	0.30
N <sub>D</sub> & N <sub>E</sub>			8
D & E	5.00 Basic		
D2 & E2	3.0		3.3
e	0.50 Basic		
L	0.30	0.40	0.50

NOTE: The package mechanical drawing is a generic drawing that applies to any pin count VFQFN package. This drawing is not intended to convey the actual pin count or pin layout of this device. The pin count and pin-out are shown on the front page. The package dimensions are in Table 8.

Reference Document: JEDEC Publication 95, MO-220

## Ordering Information

**Table 9. Ordering Information**

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
870S208BKLF	ICS870S208BL	"Lead-Free" 32 Lead VFQFN	Tray	0°C to 70°C
870S208BKLFT	ICS870S208BL	"Lead-Free" 32 Lead VFQFN	Tape & Reel	0°C to 70°C



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